On the Future Measurement of the Longitudinal Structure Function

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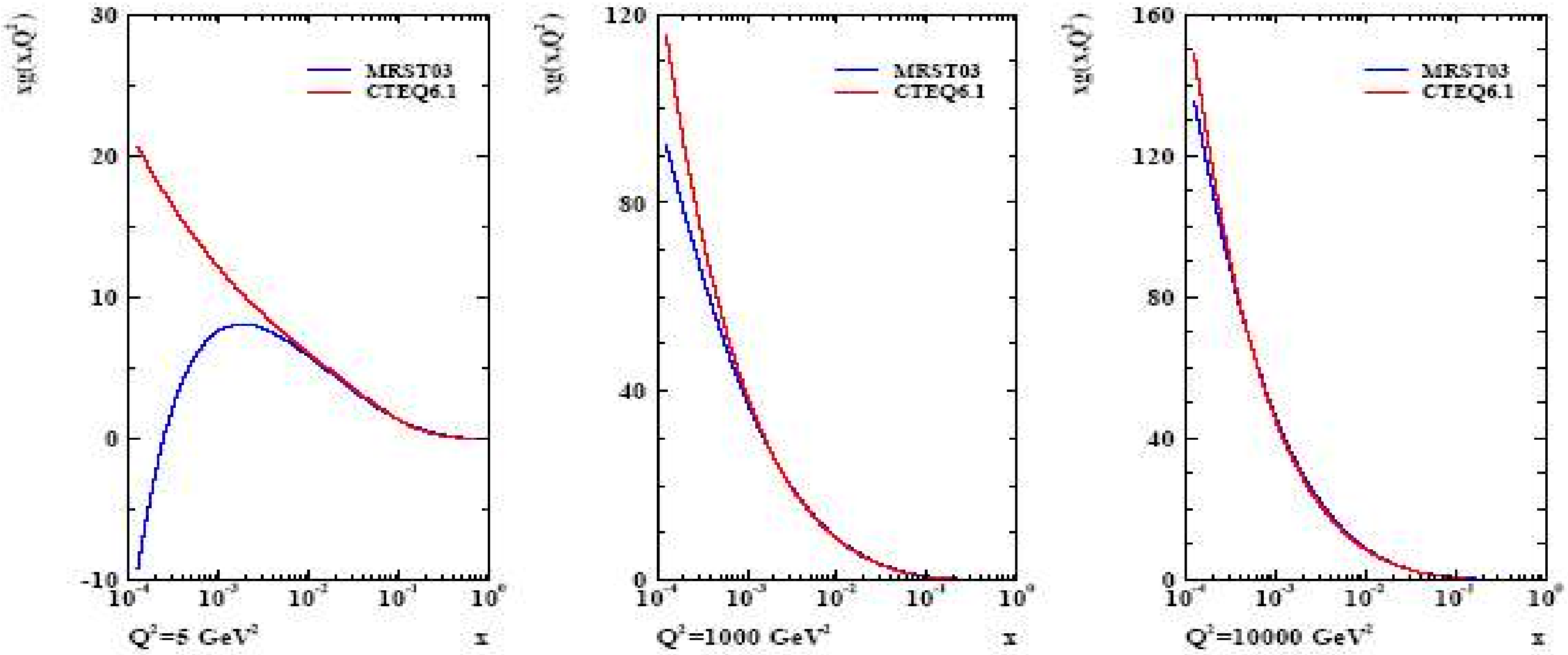
DESY Zeuthen – H1

- Why do we want to measure FL?
- What is known about FL at HERA?
- The experimental challenge
- A case study

$$\sigma_r = F_2 - y^2/[1+(1-y)^2] \cdot F_L = F_2(x,Q^2) - f(y) \cdot F_L(x,Q^2)$$

gluon distribution in recent NLO global fits

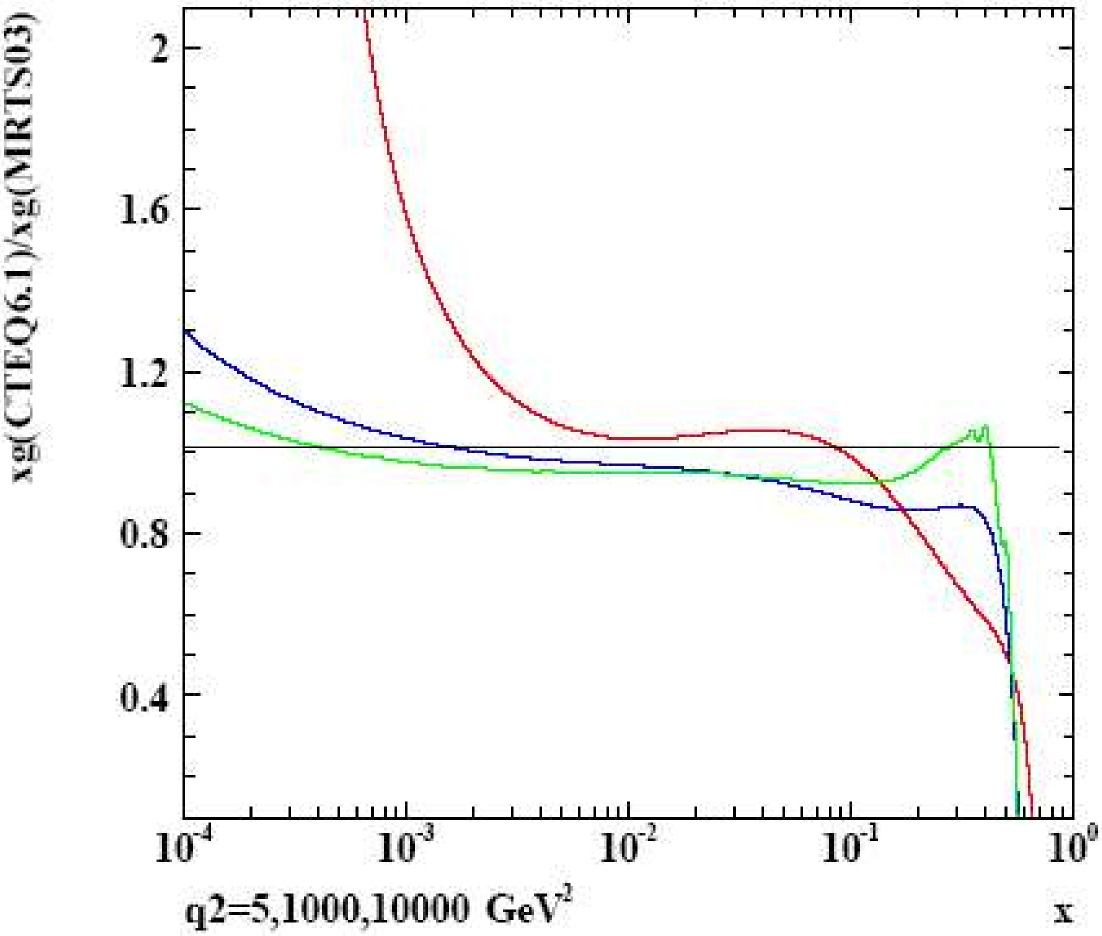


pdf's at low x determined from HERA data: xg mostly by dF2/dlnQ2

while sea quarks directly by F2: sea quarks agree but xg can be chosen

large differences at small x at low Q2 get washed out in the evolution

ratio of NLO gluon distributions at various Q2



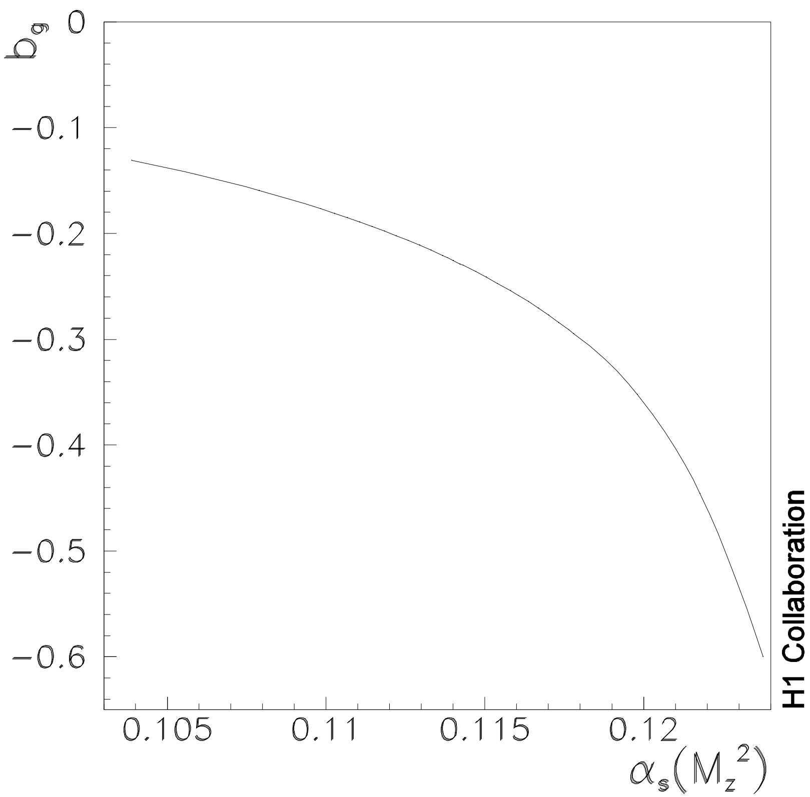
- *small x at LHC still uncertain to 10%, high x not settled either*

Correlation of alphas and xg

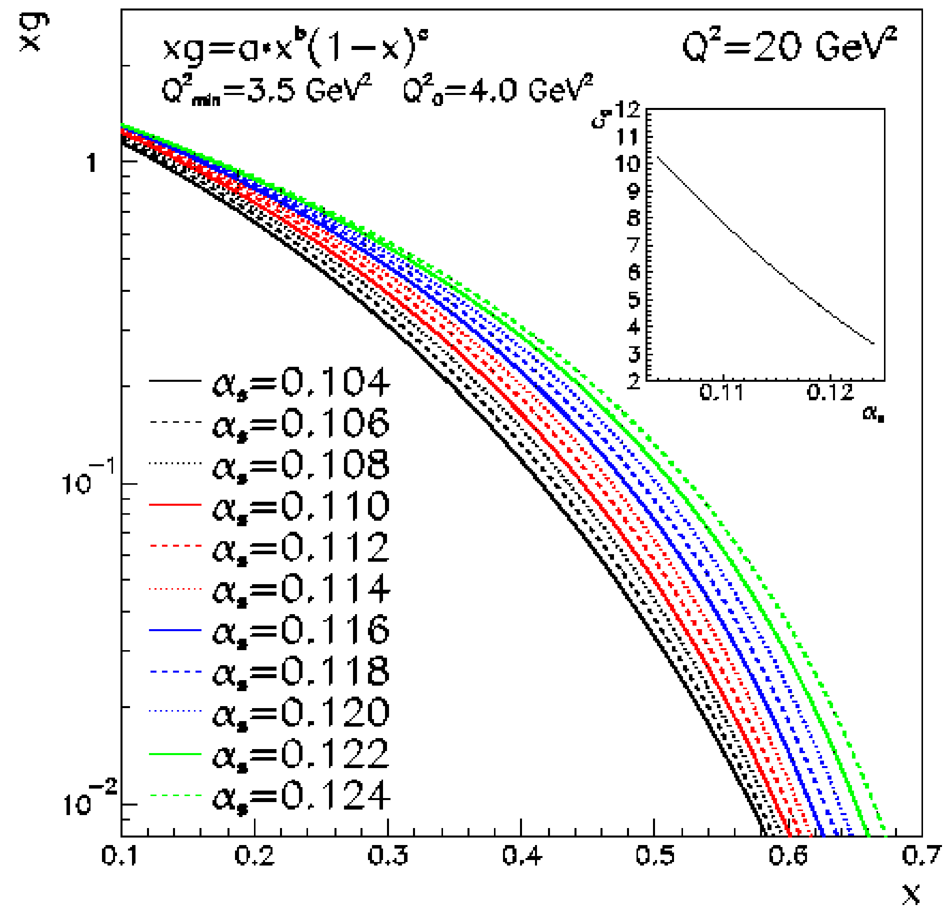
as observed in DIS fit to

H1 and BCDMS lp data

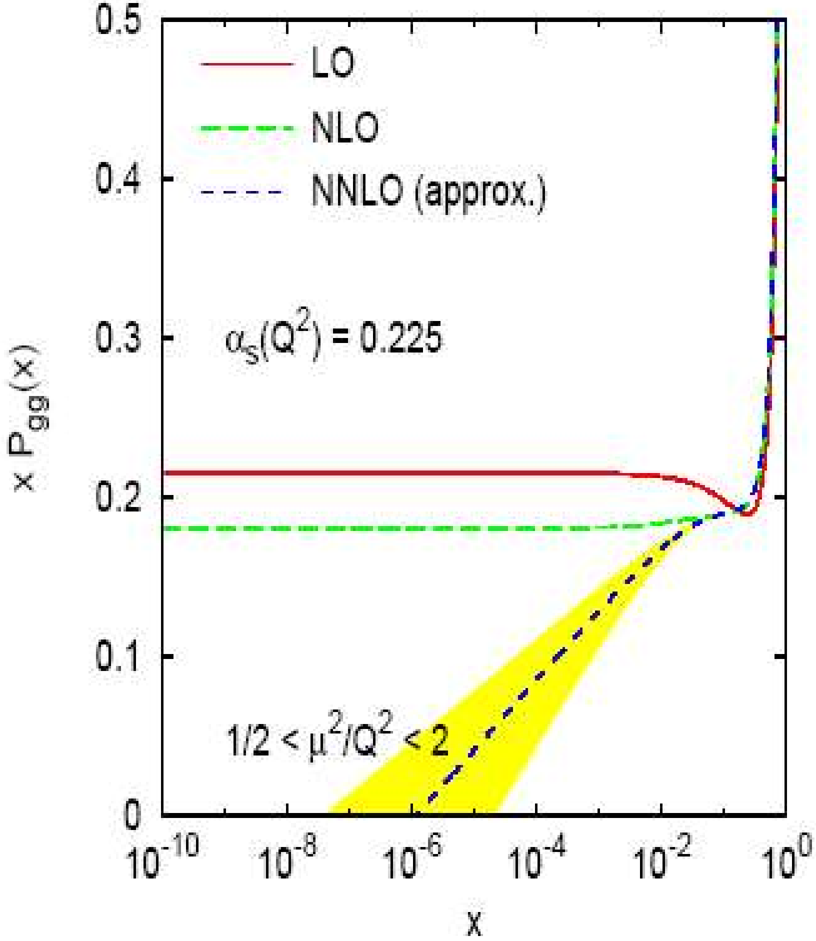
Low x FL (HERA near to 0.002)

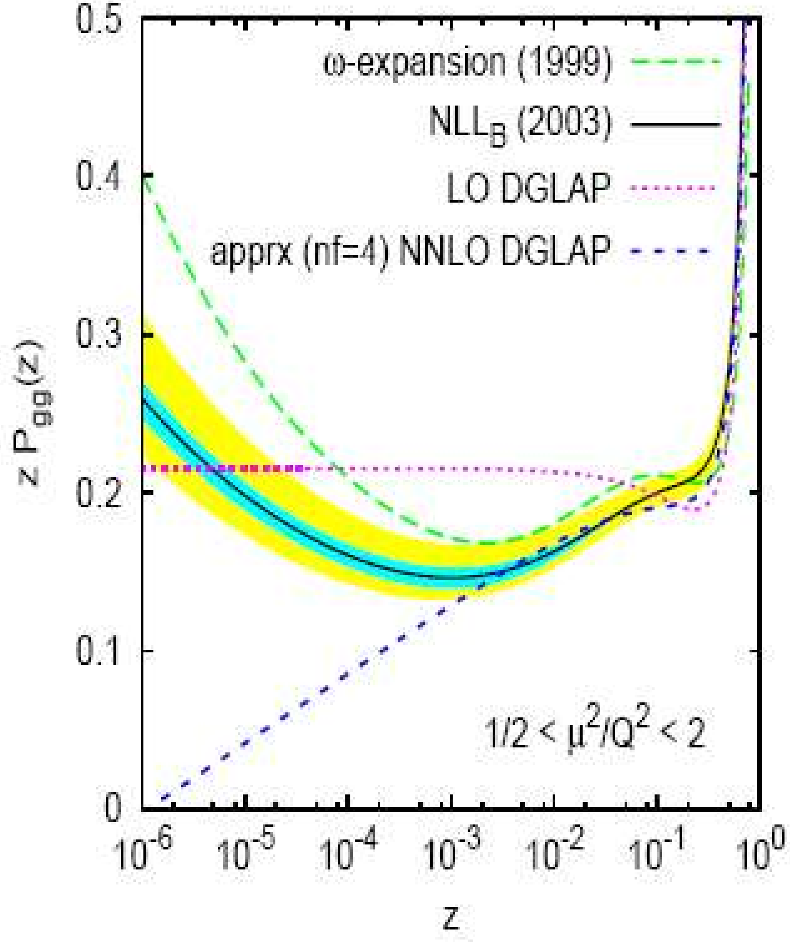


High x Jets (HERA near to 0.1) ?



The accurate determination of alphas will profit from FL(x) because the longitudinal structure function provides an independent constraint on the gluon distribution.



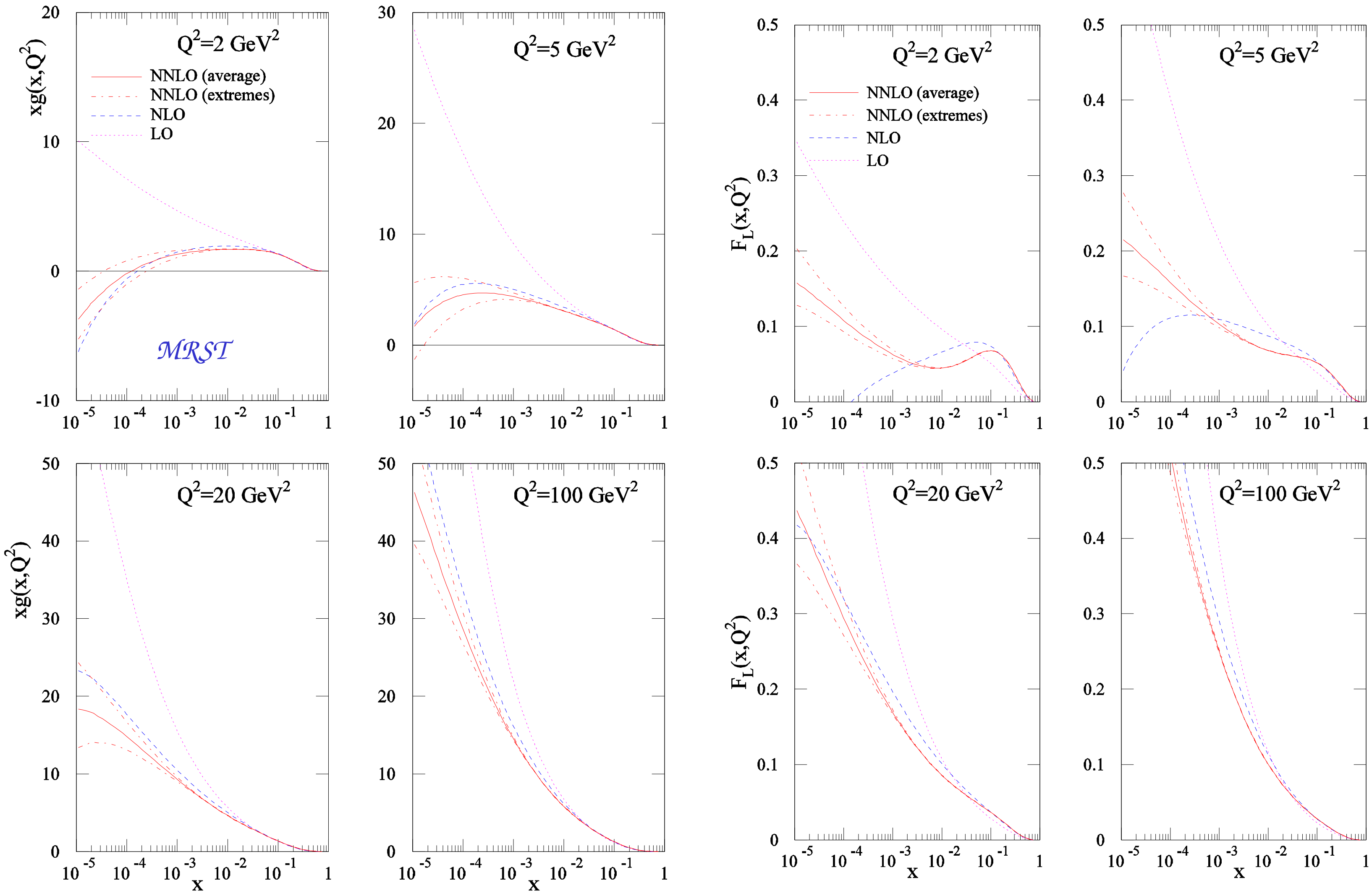


Fall and Rise of P_gg at low x: cf G. Salam at DIS04 (with Ciafaloni, Colferai, Stasto)

NNLO: see Sven Moch – this workshop

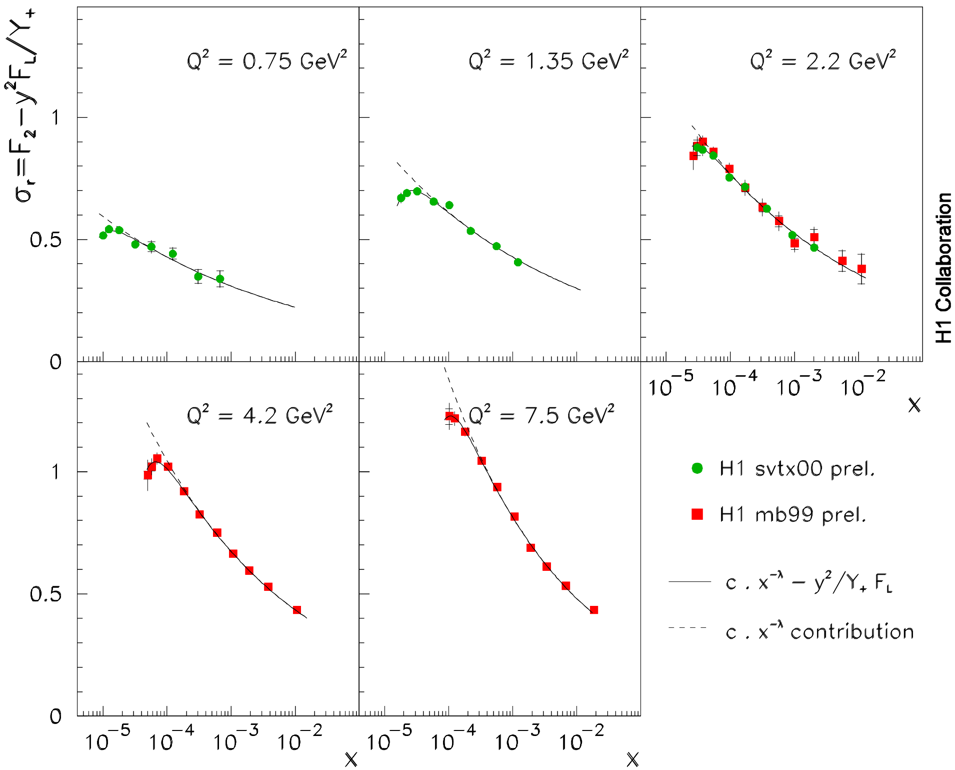
- *Gluon (splitting function) at low x needs experimental constraints*

Theory at low x is not "just" NLO DGLAP. FL provides a necessary constraint to theory and to xg at low x



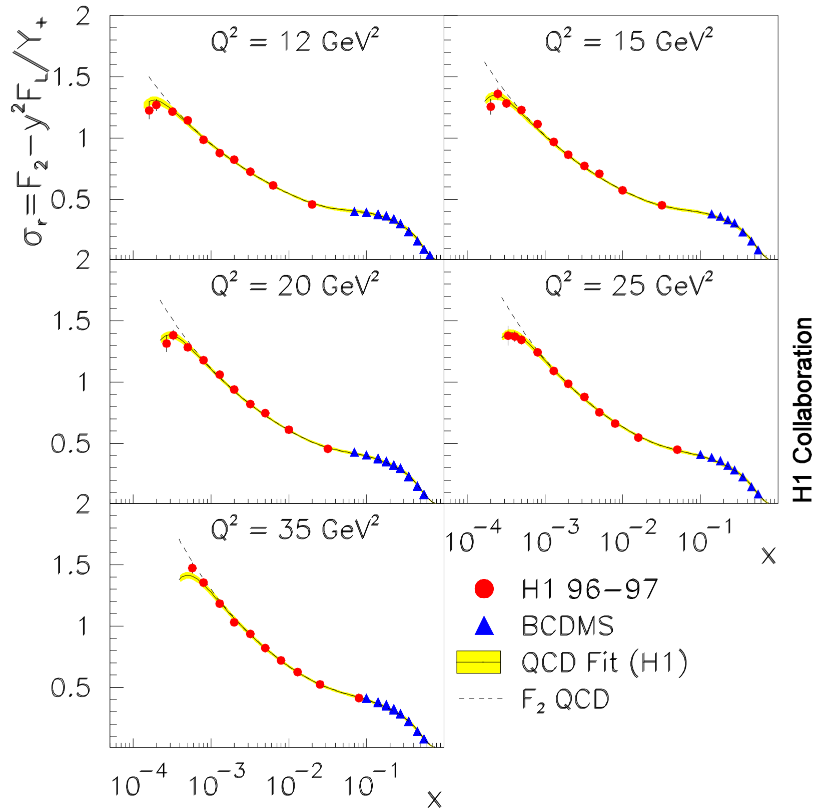
- *Why do you want to measure FL?*

- *Because it is ‘there’ Frank Sciulli*



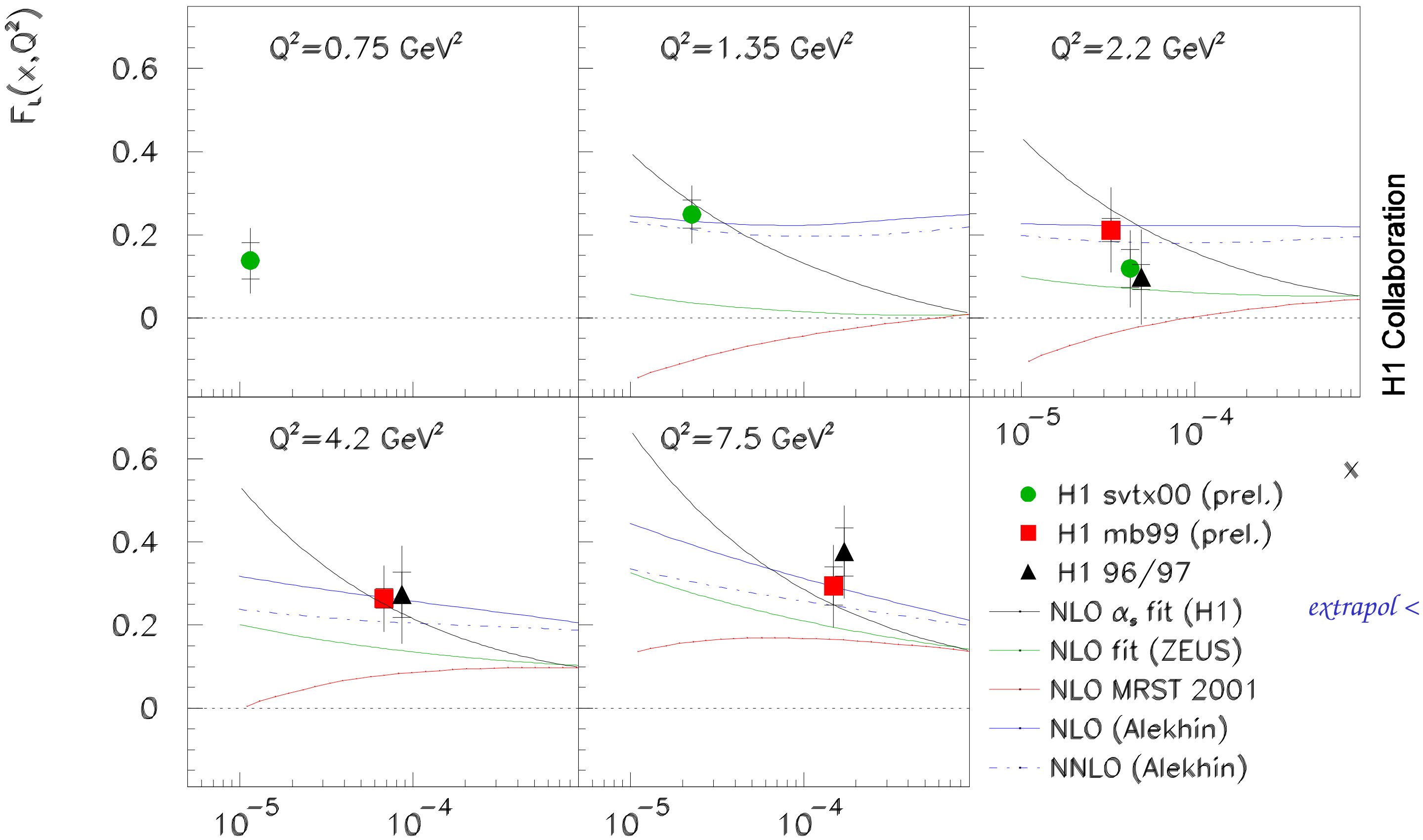
Major upgrades of H1 bwd apparatus: SpaCal + Chamber + Backward Silicon Tracker in 1995, 1997 and in 2001

$$\sigma_r = F_2(x, Q^2) - f(y) \cdot F_L(x, Q^2)$$



Measured turnover of cross section at x=Q2/sy for y about 0.5 for all Q2 FL

note: this turnover is a real constraint to QCD fits and could be given a high weight.



extrapol < 3.5 GeV2

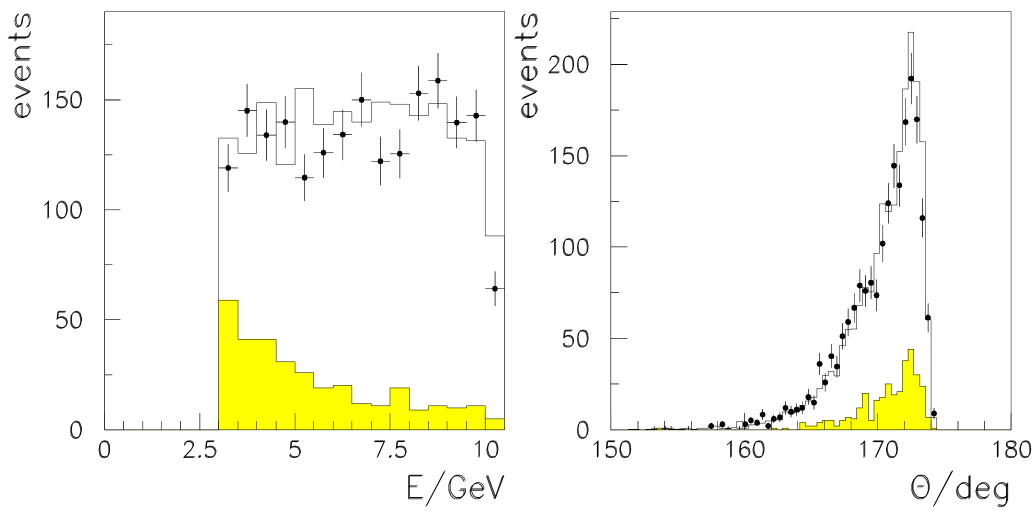
two limitations:

small x range & FL extraction needs F2,   cf. talk of E.Lobodzinska

sophisticated analysis and FL extraction

• *How to improve?*

• *Still improve accuracy: higher statistics, BST u/v wafers: p in 2pi*



SpaCal E and BST theta from 99 low Q2 data

3 GeV is about y=0.9

y=1-Ee'/Ee

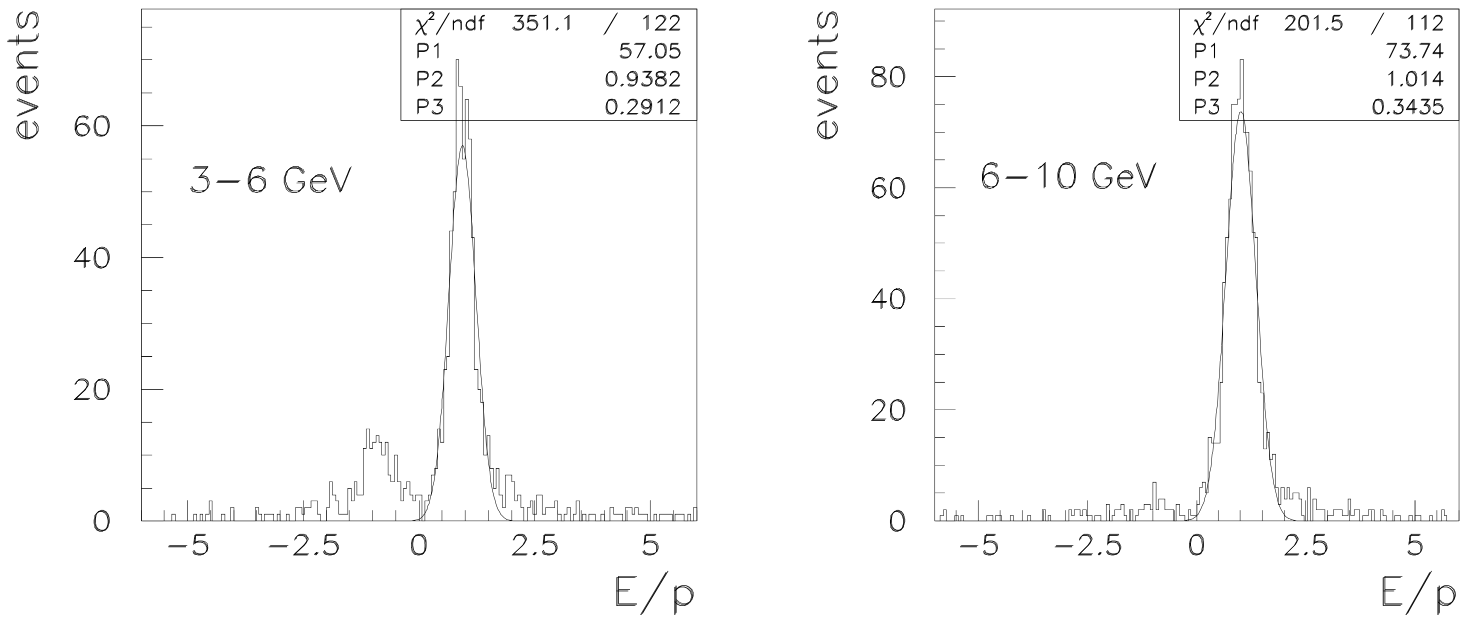
keep Ee fixed, high

lower proton beam energy

acceptance less E dep.

• *at low Ee': background from hadrons (mainly γp, also DIS) sizeable*

smaller at lowered Ep – needs simulation



SpaCal E/ BST p (pilot installation) for 99 low Q2 data

BST and CJC trackers reduce neutral background and moreover allow false charge distributions to be identified and statistically subtracted

low energy hadrons almost charge symmetric (antiprotons n.e. protons)

Simulation of FL measurement using 'Rosenbluth separation'

$$\sigma_r = F_2(x, Q^2) - f(y) \cdot F_L(x, Q^2)$$

- *measure at fixed x and Q2, varying y by changing Ep. fit xsection vs f(y)*

- *choose set of proton beam energies such that f(y) is binned equidistantly*
- *include highest Ep (920 GeV) and lowest Ep (> 330 GeV – F.Willeke)*

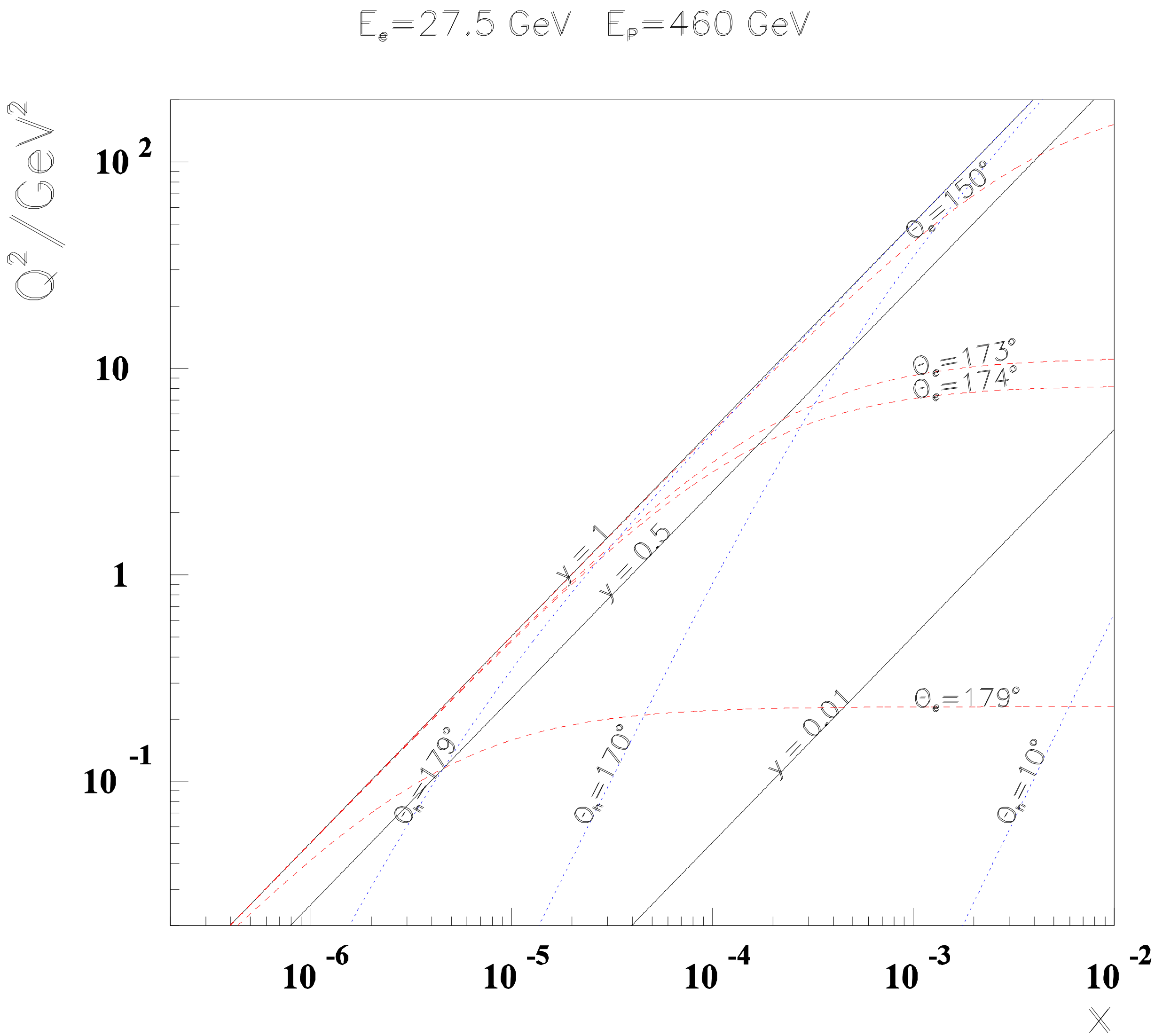
e.g. 400, 465, 575, 920 GeV

with e.g. 3 5 10 30 pb-1 case study!

[this leads to a luminosity equivalent of ~50 pb-1 from the low Ep sets.
expectations for lumi have been high: 230 pb-1 in half of 2007??
Need efficient HERA also for the low Ep programme.]

- *systematic errors assumed are as reached in the present H1 analysis of BST – SpaCal data, leading to a few % cross section accuracy*

- *distinguish between correlated and uncorrelated errors in FL extraction*



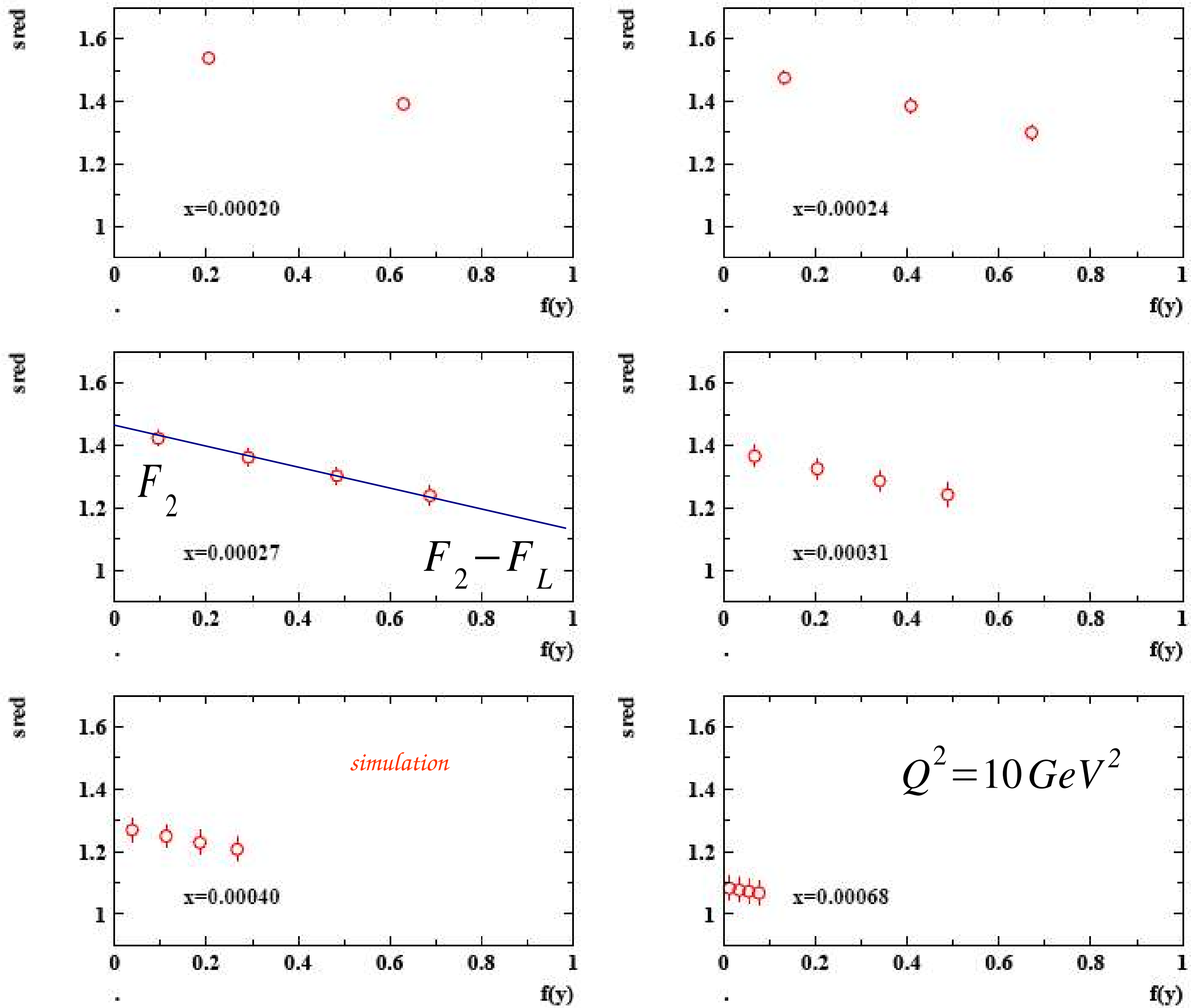
HERA II

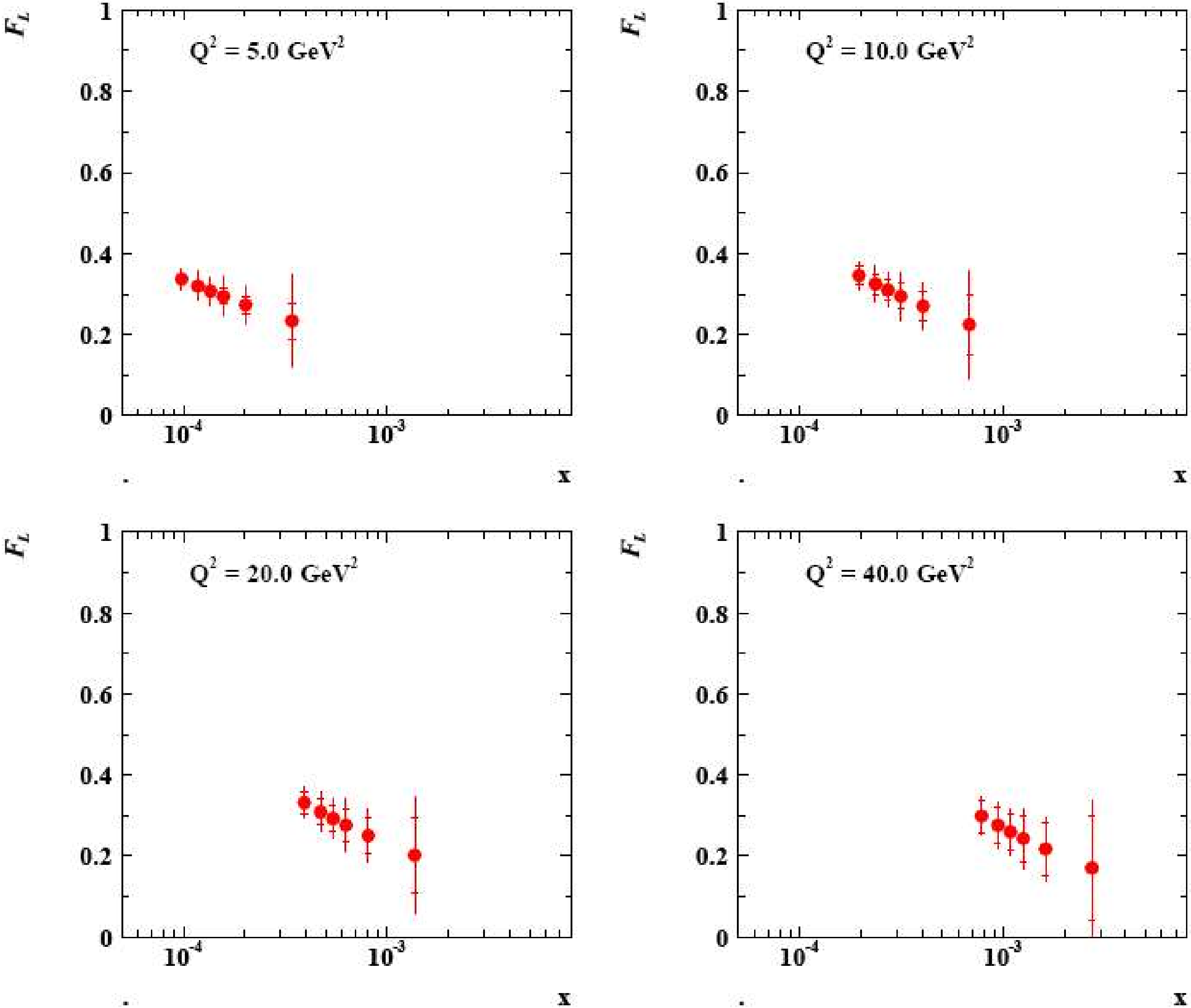
HERA III

- ***no FL data in transition region with current focussing magnets cf HERA III LoI's***

[MK at MPI workshop on H3, Dec 2002]

$$\sigma_r = F_2(x,Q^2) - f(y)\cdot F_L(x,Q^2)$$





Required Luminosity depends on Q2 intended to cover

inner error bar: stat

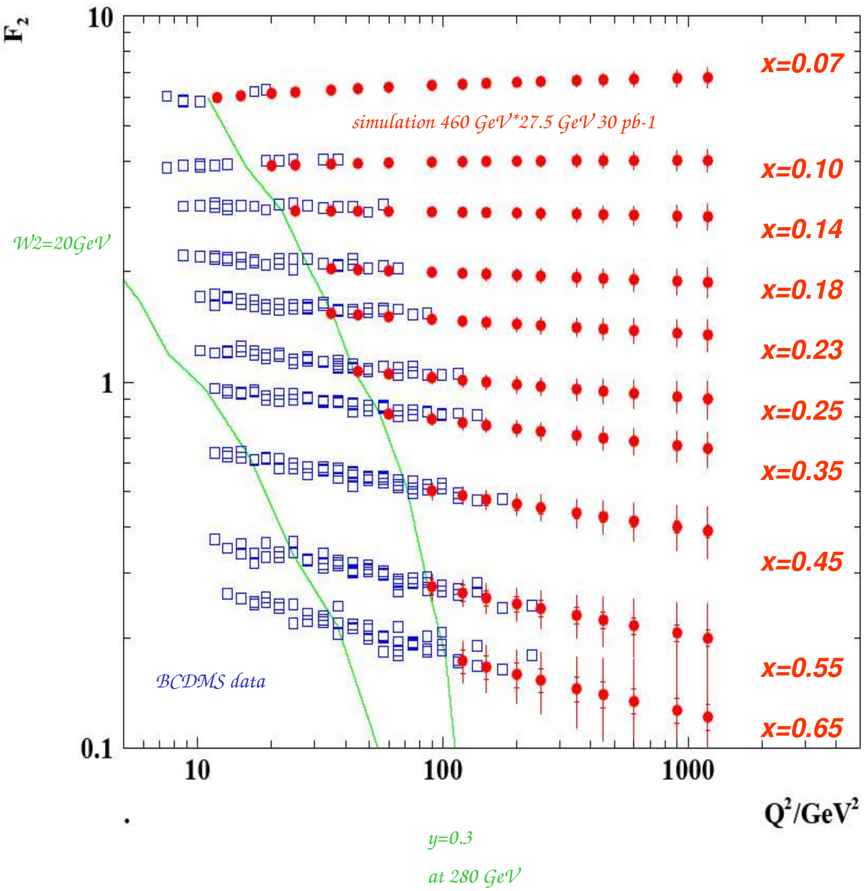
full error: stat & syst

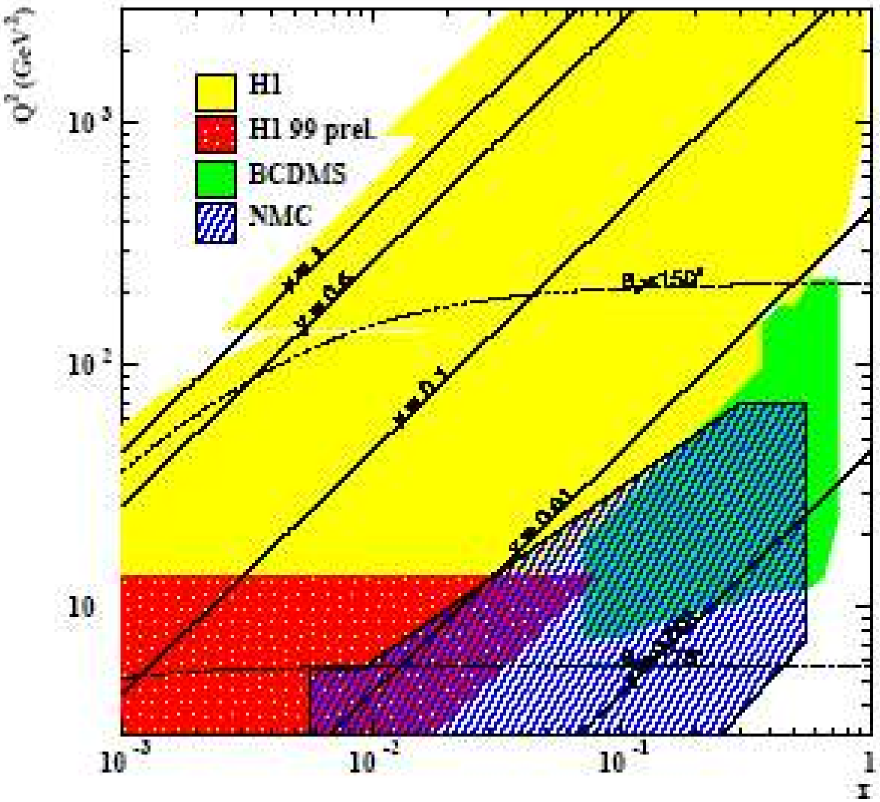
$$\delta F_L \propto \delta\sigma / y^2$$

measurement also meaningful for smaller y_min than 0.9

update of L.Bauerdick, A.Glazov, MK (HERA WS 1996/97), hep-ph/97…

also access large x at lower Q2

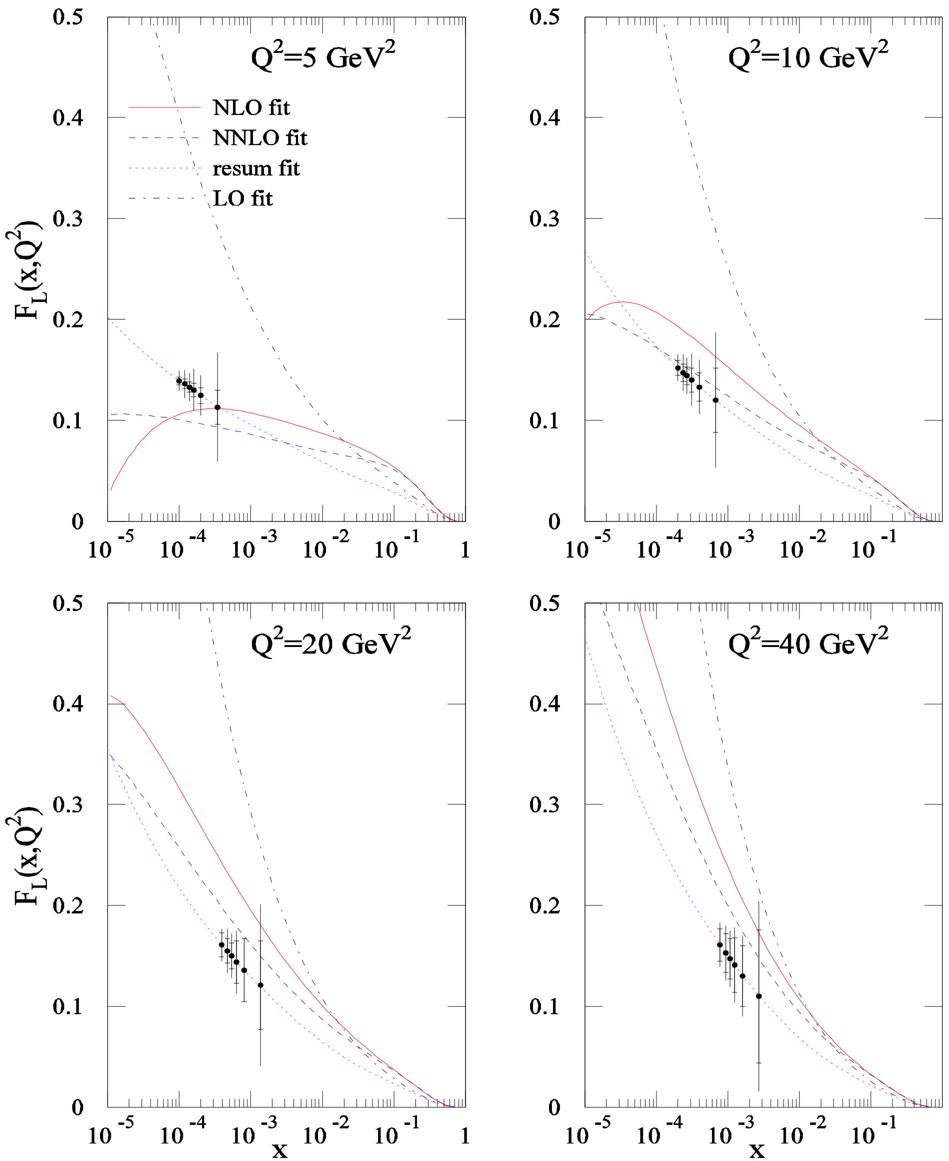




extend measurements to lowest y with

- *Simulation of resonance region (SOPHIA)*
- *Low noise calorimetry (upgraded electr.)*
- *Forward tracking (upgraded FST, FTD)*

F_L LO , NLO, NNLO and resummed - Simulation of Low E_p H1 Data



accurate FL data
at low x and Q2
are required to
test h.o.QCD and
pin down xg(x,Q2)

such a measurement
is challenging but
possible at HERA II

it delivers also data
at large x, medium Q2
besides measuring the
W,E dependence of
various cross sections

further studies needed
(HERA, MC, γp, resolutions, high x..)

R.Thorne (DIS04)